Femoral component rotation in total knee arthroplasty: an MRI-based evaluation of our options

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Introduction: Proper femoral component rotation is a crucial factor in successful total knee arthroplasty (TKA). Femoral component rotation using anatomic landmarks has traditionally been established by referencing the transepicondylar axis (TEA), Whiteside's Line (WSL), or the posterior condylar axis (PCA). TEA is thought to best approximate the flexion-axis of the knee. However WSL or PCA are commonly used as surrogates of the TEA in the operating room due to their accessibility. The relationship of these anatomic landmarks has been previously investigated in anatomic and computed tomography based studies. The relatively few knees evaluated have limited the power of these studies. Customized instrumentation utilizing magnetic resonance imaging (MRI) is an emerging technology in total knee replacement. MRI's provide an accurate method of identifying and comparing the anatomic landmarks used to establish femoral rotation in TKA. The purpose of this study was to use magnetic resonance imaging based planning software to assess the relationship of WSL and PCA to the TEA and to determine if the relationships were influenced by the magnitude of the pre-operative coronal deformity.

Methods: Three hundred eighty-five total knee replacements were performed in 336 patients utilizing customized instrumentation. A Patient Specific Instrumentation system was utilized in conjunction with the Materialize preoperative planning software. The rotational relationships of TEA, WSL, and PCA were determined using the planning software (Fig 1). The coronal plane deformity of each patient was also evaluated utilizing the MRI-based imaging and planning software.

Results: The WSL is externally rotated by 90.56 compared to the TEA and the PCA is 2.31 degrees internally rotated compared to the TEA in the overall population ($p<0.001$). In Varus patients, WSL has a standard deviation (SD) of 2.4 degrees from the TEA whereas PCA has a SD of 1.56 degrees from the TEA (Figure 1). Only 65% of patients will have a WSL value that deviates no more than 2.4 degrees from the TEA. However 83% of patients will have a PCA that deviates no more than 2.4 degrees from the TEA. Increasing coronal plane deformity does not appear to influence the rotational relationships of the axis choices. Gender also does not appear to influence the rotational relationships of the axis choices.

Discussion: Femoral component rotation is determined based on one of three axis options. Classic studies have shown that the TEA is perpendicular to the WSL and the PCA is 3 degrees internally rotated to the TEA. However, there is wide variation in the relationships. Our MRI based evaluation shows that both WSL and PCA approximate the TEA in valgus knees regardless of the degree of deformity. Our study also shows that on average the PCA is 2.3 degrees internally rotated compared to the TEA, not the previously assumed 3 degrees. Furthermore, in valgus deformity greater than 7.5 degrees, the PCA is only 2.6 degrees internally rotated compared to the TEA. This is in stark contrast to the normal 5 degrees that is described in the literature when utilizing the PCA in valgus knees and should be taken into account when using posterior referencing in conventional TKA. In all patients, the PCA has a smaller standard deviation from the TEA than WSL does. The SD of PCA from TEA is 1.6 degrees while the SD of WSL from TEA is 2.3 degrees. Thus PCA more reliable approximates the TEA than does WSL in all patient populations. Advanced imaging can assist surgeons in assessing

their options for femoral component rotation in TKA. Our data indicates that the relationships of axis options may need to be reassessed as imaging technology advances.

Figure 1: Rotational Variation of TEA vs. WSL compared to variation of TEA vs. PCA. 65% of patients will have TEA within 4.8 degrees of WSL compared to 83% of patients will have PCA within 4.8 degrees of TEA.